Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Tribulus terrestris* L. (USDA 2005)
Synonyms:	None identified in USDA (2005).
Common names:	Puncturevine, bullhead, goathead, Mexican sandbur, Texas sandbur, caltrop, tackweed, ground burnut
Evaluation date (mm/dd/yy)**:**	05/01/03
Evaluator #1 Name/Title:	Katy Brown
Affiliation:	Nature Conservancy
Phone numbers:	(520) 622−3861
Email address:	pbrown5@mindspring.com
Address:	1510 E. Ft. Lowell Rd., Tucson, Arizona 85713
Evaluator #2 Name/Title:	Dana Backer, Conservation Ecologist
Affiliation:	Nature Conservancy
Phone numbers:	(520) 622−3861 ext 3473
Email address:	dbacker@tnc.org
Address:	1510 E. Ft. Lowell Rd., Tucson, Arizona 85713

List committee members:	D. Backer, C. Barclay, K. Brown, P. Guertin, F. Northam, R. Parades, W. Sommers, J. Ward, P. Warren
Committee review date:	09/19/03
List date:	09/19/03
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**D**	Other published material	**"Impact"** **Section 1 Score:** **D**	**"Plant Score"** **Overall Score:** **Evaluated but not listed** **Alert Status:** **None**
1.2	Impact on plant community	**D**	Other published material		
1.3	Impact on higher trophic levels	**D**	Observational		
1.4	Impact on genetic integrity	**D**	Other published material		
2.1	Role of anthropogenic and natural disturbance	**C**	Other published material	**"Invasiveness"** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **9 pts** **Section 2 Score:** **C**	
2.2	Local rate of spread with no management	**U**	Observational		
2.3	Recent trend in total area infested within state	**D**	Observational		
2.4	Innate reproductive potential	**A**	Reviewed scientific publication		
2.5	Potential for human-caused dispersal	**B**	Other published material		
2.6	Potential for natural long-distance dispersal	**B**	Other published material		
2.7	Other regions invaded	**C**	Other published material		
3.1	Ecological amplitude	**U**	Observational	**"Distribution"** **Section 3 Score:** **U**	RED FLAG **NO** Something you should know.
3.2	Distribution	**U**	Observational		

Table 3. Documentation

Note: Questions 3.1 and 3.2 below were each assigned a score of **U** based on Working Group consensus. A **U** score was assigned because *Tribulus terrestris* is naturalized—that is, self-sustaining populations occur without direct intervention by humans, but the species does not necessarily invade natural, semi-natural, human-made ecosystems (Richardson et al. 2000)—throughout Arizona and exists in association with several ecological types, but its known occurrences are within the anthropogenically disturbed areas where it is known to be present. Working Group members could not identify an ecological type outside of urban or wildland-urban interface areas where *T. terrestris* was known to invade or exist. This is not to say that it does not exist in natural areas or working landscapes. If a soil disturbance is present within an area, *T. terrestris* has the potential to invade. Criteria standards assign all species with a **D** rating in section one (questions 1.1 through 1.4) an overall score of "**Evaluated but not listed**." As a result, even if the responses to questions 3.1 and 3.1 were different—even including a score of **A** for both questions—they would not affect the overall score. Working Group follow-up on Consistency Review Panel comments did not alter the score for section one.

The Working Group concluded having the above documentation was relevant, because *T. terrestris* represents a unique case. It is distinguishable from those species that are clearly present within wildlands in a variety of ecological types, but whose specific frequency of occurrence within these ecological types may be unknown. In contrast, *T. terrestris* may occur in juxtaposition to a variety of ecological types, but clear documentation is lacking that it actually occurs within the wildland occurrences of these types.

Question 1.1 Impact on abiotic ecosystem processes *Score:* **D** *Doc'n Level:* **Other pub.**
Identify ecosystem processes impacted: Negligible impacts to soil temperature and moisture.
Rationale: From Holm et al. (1991): water requirements of *T. terrestris* are low compared with other plants (assumed to be crops). In studies in Texas, Davis and Wiese (1964) found *T. terrestris* required 96 kg of water to produce 1 kg of dry matter as contrasted with sorghum or alfalfa that require about 300 to 840 kg of water to produces 1 kg of dry matter. Davis et al. (1965) found *T. terrestris* to be able to extract 14.1 kg of water per plant in excess of the rainfall received, this amount indicating an ability of the plant to remove water from soil at very high moisture tension (experiments were conducted in agricultural settings). *Tribulus terrestris* forms a taproot thus providing the mechanism for acquiring (requiring) more water. Holm et al. (1991) also suggest that problems and losses due to *T. terrestris* are of economic concern, predominately agriculture, because of the plant's ability to extract soil moisture from great depths. Roots can develop nitrogen-fixing nodules (CDFA 2003). Other reviews of the literature do not suggest there is an impact on natural abiotic processes.
Sources of information: See cited literature.

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **D** *Doc'n Level:* **Other pub.**
Identify type of impact or alteration: Negligible.
Rationale: From Guertin and Halvorson (2003): in Australia, sensitive to competition typically where perennial plants are maintained (Squires 1969). In India, it was noted that *T. terrestris* does not grow in continuous patches and is associated with sunny locations on a site (Pathak 1970). When it is observed in continuous patches on a site, the competition is low on the site (Pathak 1970). F. Northam (personal communication, 2003) commented that *T. terrestris* can be problematic for restoration projects.
Sources of information: See cited literature. Also considered personal communication with F. Northam (Noxious Weed Coordinator, Arizona Department of Agriculture, 2003).

Question 1.3 Impact on higher trophic levels	*Score:* **D** *Doc'n Level:* **Obs.**
Identify type of impact or alteration: Negligible; human nuisance, injurious to grazing animals, foliage toxic to livestock.	
Rationale: Impacts to grazing animals: foliage toxic (Schmutz et al. 1968 in Holm et al. 1991, CDFA 2003) and grazing animals [ungulates] eat burrs, which causes injuries to mouth, stomach, and intestines (WSNWCB 2001). No known studies on native fauna. Ants seem to congregate under plants and particularly near stem emergence (Working Group member observations). The species is out-competed by native forage, does not occur as continuous coverage, and is sensitive to competition. It is known predominantly from disturbed areas. The presumed impact on higher trophic levels is inferred to be negligible (Working Group inference).	
Sources of information: See cited literature. Documentation level is observational based on inference by the Working Group, because impacts have not been directly observed on native fauna and the species rarely exists outside of agricultural and urban settings.	

Question 1.4 Impact on genetic integrity	*Score:* **D** *Doc'n Level:* **Other pub.**
Identify impacts: No known hybridization.	
Rationale: No known hybridization and no native *Tribulus* in Arizona. Native caltrop (*Kallstroemia)* looks similar but flowers at different times of year.	
Sources of information: Kearney and Peebles (1960).	

Question 2.1 Role of anthropogenic and natural disturbance in establishment	*Score:* **C** *Doc'n Level:* **Other pub.**
Describe role of disturbance: *Tribulus terrestris* requires disturbance to establish and is most often associated with an anthropogenic disturbance.	
Rationale: Habitat is disturbed places, along streets, roadsides, railways, cultivated fields and orchards, pastures, lawns and yards, waste places, walk ways, etc.	
Sources of information: See CDFA (2003), Parker (1972) and Hickman (1993) in Guertin and Halvorson (2003).	

Question 2.2 Local rate of spread with no management	*Score:* **U** *Doc'n Level:* **Obs.**
Describe rate of spread: Unknown.	
Rationale: Because *Microlarinus lareyneii* and *M. lypriformis* were introduced as a biocontrol agents in 1957 it is not known what the local spread would be with no management. As a result, because a biocontrol is currently in place, we do not known the rate of spread as of the last 20 to 30 years. From Gould and DeLoach (2002): these weevils became established in Arizona and California. The project has been considered a substantial success in non-irrigated areas, and a partial success overall. Fifteen years after the introduction of the weevils, the coverage and seed production of *T. terrestris* had declined more than 80% in twelve hundred field plots in California (Huffaker et al. 1983). The weevil was introduced into California and Nevada in 1961 and shortly thereafter in several other western states (does not mention which western states; Huffaker et al. 1961).	
Sources of information: See cited literature. Score based on inference based on the literature by the Working Group.	

Question 2.3 Recent trend in total area infested within state	*Score:* **D** *Doc'n Level:* **Obs.**
Describe trend: Declining.	

Rationale: Because of the success of the weevil, it is thought that the extent of infestation is declining overall. Where infestation is occurring in new areas, it is within areas of anthropogenic disturbance and not within wildlands.
Sources of information: Working Group inference based on literature cited in question 2.2.

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Rev. sci. pub.**
Describe key reproductive characteristics: High viable seed output; viable after dormancy; can reproduce by both cross- and self-pollination; staggered germination; long-range dispersal; temperature and water limited; competition sensitive.
Rationale: Due to both cross pollination (CDFA 2003) and self pollination with seed set there is a potential of 100% reproduction capability (Reddi et al. 1981). Boydston (1990) reports that plants produced from 200 to 5600 burrs/plant and each burr contains up to 5 nutlets, and each nutlet can contain 2 to 5 seeds. Fruits only 10 days old potentially have viable seeds (Johnson 1932 in Squires 1979, as cited in Guertin and Halvorson 2003). Seeds remain viable for several years (CDFA 2003), staying dormant in the soil for 4 to 5 years (Whitson 1992). Seeds emerge at similar or increasing levels over several years from a given year's seed crop, which may enable *T. terrestris* to persist in spite of weed control programs (Boydston 1990). Seedlings emerge during early spring through summer, often in flushes following increased soil moisture (CDFA 2003).
Sources of information: See literature citations; original sources of information not available and therefore Guertin and Halvorson (2003) was used as a review of the literature.

Question 2.5 Potential for human-caused dispersal *Score:* **B** *Doc'n Level:* **Other pub.**
Identify dispersal mechanisms: Moderate potential based on fruit morphology and mechanism for dispersal.
Rationale: Spiny fruits are weed's primary means of dissemination-arrangement, length and angle of spines ensures placement on tires (vehicles, bikes, airplanes), shoes, clothing, pets, etc. Mountain bikes and off-road vehicles pose a potential threat to dispersing seeds into wildlands and at distances greater than 1 km. Due to the lack of studies or reports commenting on *T. terrestris* in wildlands and based on fruit morphology, it is inferred to have a moderate human caused dispersal rate. Can also be found in contaminated seed and feed (Johnson 1932 in Gould and Deloach 2002)
Sources of information: See cited literature; also see citations in Guertin and Halvorson (2003) and Holm et al. (1991).

Question 2.6 Potential for natural long-distance dispersal *Score:* **B** *Doc'n Level:* **Other pub.**
Identify dispersal mechanisms: Animals and possibly water.
Rationale: From Guertin and Halvorson (2003): fruits easily attach to animals fur thus facilitation long distance dispersal (it is not stated but the assumption is livestock fur). Sources of information in Guertin and Halvorson (2003): Ernst and Tolsma (1988), Squires (1979), and Whitson (1992). Fruits can also imbed themselves in hooves and feet a subsequently break off when animals try to rid themselves of the irritation (Ridley 1930). It was suggested by Working Group members that fruits of *T. terrestris* could float in water and be dispersed >1 km but no documentation was found to support this idea.
Sources of information: See cited literature.

Question 2.7 Other regions invaded	*Score:* **C** *Doc'n Level:* **Other pub.**
Identify other regions: Same ecological types invaded elsewhere.	
Rationale: Throughout California to Wyoming, eastern U.S., Central Mexico (Johnson 1932 In: CDFA 2003). Found most commonly in pastures, roadsides, orchards, vineyards, waste places, parks, railway yards and agricultural areas. In tropical regions *T. terrestris* develops woody roots and becomes perennial (CDFA 2003). Occurs in areas with mean annual minimum precipitation of 11 inches and maximum precipitation of 15 inches (Rice 2002). Requires relatively high temperatures for growth (WSNWCB 2001) and is intolerant of freezing temperatures (Squires 1979 in Guertin and Halvorson 2003, CDFA 2003). Can be killed by frost or drought (Squires 1979 in Guertin and Halvorson 2003). Adapted to warm and temperate regions (WSNWCB 2001). Prevalent in areas with hot summers on dry soils (CDFA 2003). Requires high temperatures and prefers dry, sandy soils but tolerates most soil types (WSNWCB 2001, CDFA 2003).	
Sources of information: See cited literature.	

Question 3.1 Ecological amplitude	*Score:* **U** *Doc'n Level:* **Obs.**
Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: In Arizona, *T. terrestris* is found below 7000 feet (Parker 1972). *Tribulus terrestris* habitat is disturbed places, along city streets and roadsides, railways, cultivated fields and orchards, pastures, lawns and yards, waste places, walkways (Parker 1972, Hickman 1993, CDFA 2003). Several herbarium records (SEINet 2003) exist from pine-oak woodlands; locales with elevations documented at 3500 feet at Coyote Mountain (present along with *Acacia* sp., *Prosopis* sp, and *Fouquieria splendens*) and at 6900 feet (Apache County), and at Havasu Canyon, lower Bonita Canyon in the Chiricahua National Monument, and Diamond Creek in Grand Canyon National Park. None of these records, however, specify whether the occurrence is independent of anthropogenic disturbance. Foy et al. (1983 in Guertin and Halvorson 2003) reports "presumably" [*Tribulus*] was unintentionally imported into U.S. on military planes from the Sahara Desert region and other reports suggest it was accidentally imported from the Mediterranean into the U.S. on livestock (Andres and Goeden 1995 in Gould and DeLoach 2002). First reported in California in 1903 (Davidson 1903 in Squires 1979 in Guertin and Halvorson 2003). First record noted in the University of Arizona herbarium was for 1905 (SEINet 2003).	
Rationale: Restricted to disturbed areas. Because the ecological amplitude of *T. terrestris* is so broad, it can invade most ecological types in Arizona when they are anthropogenically disturbed to a significant degree (that is, the species generally would not occur in natural areas). Because Working Group members could not identify an ecological type outside of urban or wildland-urban interface areas where *T. terrestris* was known to invade or exist, a score of **U** was assigned for each ecological type that an occurrence of *T. terrestris* was documented as occurring nearby (see Worksheet B).	
Sources of information: See cited literature. Also considered information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed 2003). Score based on the literature, observations, and inference by Working Group members.	

Question 3.2 Distribution	*Score:* **U** *Doc'n Level:* **Obs.**
Describe distribution: Found throughout Arizona (Kearney and Peebles 1960, Parker 1972, McDougall 1973).	
Rationale: See comments under question 3.1.	

Sources of information: Score based on the literature, observations, and inference by Working Group members.

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	**Yes**	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	**Yes**	**No**	**2 pt.**
Populations of this species produce seeds every year.	**Yes**	**No**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	**Yes**	**No**	**1 pt.**
Seeds remain viable in soil for three or more years	**Yes**	**No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**Yes**	**No**	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**Yes**	**No**	**1 pt.**
Fragments easily and fragments can become established elsewhere	**Yes**	**No**	**2 pt.**
Resprouts readily when cut, grazed, or burned	**Yes**	**No**	**1 pt.**

Total pts: 8 Total unknowns: 0

Score : A

Note any related traits:

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	**U**
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	
	semi-desert grassland	
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	**U**
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	**U**
	montane riparian	
Woodlands	Great Basin conifer woodland	
	Madrean evergreen woodland	**U**
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

Literature Cited

Andres, L.A., and R.D. Goeden. 1995. Puncture vine. In J.R. Nechols and others (eds), Biological Control in the Western United States: Accomplishments and Benefits of Regional Research Project W-84, 1964–1989. University of California Publication 3361.

Boydston, R.A. 1990. Time of emergence and seed production of Longspine sandbur (*Cenchrus longispinus*) and Puncture vine (*Tribulus terrestris).* Weed Science 38:16–21.

Brown, D.E. (ed.). 1994. Biotic Communities: Southwestern United States and Northwestern Mexico. University of Utah Press, Salt Lake City. 342 p. [Plus companion 60-inch by 48-inch map, Biotic Communities of the Southwest].

Brown, D., F. Reichenbacher, and S. Franson, S. 1998. A Classification of North American Biotic Communities. University of Utah Press, Salt Lake City. 141 p.

[CDFA] California Department of Food and Agriculture. 2003. *Tribulus*. In E.A. Healy, S. Enloe, J.M. DiTomaso, B. Roberson, N. Dechoretz, S. Schoenig, P. Akers, L. Butler, and J. Garvin (eds.), Encycloweedia. Non-Cropland Weed group, University of California Extension Service, Weed Science Program, Department of Vegetable Crops, The University of California, Davis, California. Available online at: http://pi.cdfa.ca.gov/weedinfo/TRIBULUS2.htm.

Davidson, A. 1903. New plant records for Los Angeles County, Part II. Southern California Academy of Science Bulletin 2:43.

Davis, R., and A. Wiese. 1964. Weed root growth patterns in the field. Pages 367–368 in H. Andrews (ed.), Proceedings of the 17th Southern Weed Conference. University of Tennessee, Knoxville.

Davis, R., A. Wiese, J. Pafford. 1965. Root moisture extraction profiles of various seeds. Weeds 13:98–100.

Ernst, W.H., and D.J. Tolsma. 1988. Dormancy and germination of semi-arid annual plan species, *Tragus berteronianus* and *Tribulus terrestris*. Flora 181(3/4):243–251.

Foy, C.L., D.R. Forney, and W.E. Cooley. 1983. History of weed introductions. In C.L. Wilson and C.L. Graham (eds.), Exotic Plant Pests and North American Agriculture. Academic Press, New York. 522 p.

Gould, J.R., and C.J. DeLoach. 2002. Biological control of invasive exotic plant species; protocol, history, and safeguards. Pages 284–306 in B. Tellman (ed.), Invasive Exotic Species in the Sonoran Region. The University of Arizona Press and the Arizona-Sonora Desert Museum, Tucson.

Guertin, P., and W.L. Halvorson. 2003. Status of Fifty Introduced Plants in Southern Arizona Parks. U.S. Geological Survey, Sonoran Desert Research Station, School of Natural Resources, University of Arizona, Tucson. Available online at: http://sdrsnet.srnr.arizona.edu/index.php?page=datamenu&lib=2&sublib=13; accessed November 2004.

Hickman, J.C. (ed.). 1993. The Jepson Manual: Higher Plants of California. University of California Press, Berkeley. 1400 p.

Holm, L.G., D.L. Plucknett, J.V. Pancho, and J.P. Herberger. 1991. The World's Worst Weeds: Distribution and Biology. Krieger Publishing Company, Malabar, Florida. 609 p.

Huffacker, C.B, D.W. Ricker, and C.E. Kennett. 1961. Biological control of puncturevine with imported weevils. Calif. Agric. 15:11–12.

Huffacker, C.B., J. Hamai, R.M. Nowierski. 1983. Biological control of puncturevine, *Tribulus terrestris*, in California after twenty years of activity of introduced weevils. Entomophaga 28:387–400.

Johnson, E. 1932. The puncture vine in California. Agricultural Experiment Station Bulletin 528. University of California, College of Agriculture.

Kearney, T.H., and R.H. Peebles (and collaborators). 1960. Arizona Flora. 2nd edition with supplement by J.T. Howell and E. McClintock and collaborators. University of California Press, Berkeley. 1085 p.

McDougall, W.B. 1973. Seed Plants of Northern Arizona. The Museum of Northern Arizona. Flagstaff. 594 p.

Parker, K.F. 1972. An Illustrated Guide to Arizona Weeds. The University of Arizona Press, Tucson. 338 p. Available online at http://www.uapress.arizona.edu/online.bks/weeds/puncture.htm; accessed July 2003.

Pathak, P.S. 1970. Contributions to the ecology of *Tribulus terrestris* Linn. II. Habitat studies. Agra University Journal of Research Science 19:149–166.

Reddi, C.S., E.U. Reddi, and N.S. Reddi. 1981. Breeding structure and pollination ecology of *Tribulus terrestris*. Proceedings of the Indian National Science Academy, Part B 47:185–193.

Rice, P.M. 2002. INVADERS Database System, University of Montana, Division of Biological Sciences, Missoula, Montana. Available online at: http://invader.dbs.umt.edu.

Richardson, D.M., P. Pyšek, M. Rejmánek, M.G. Barbour, F.D. Panetta, and C.J. West. 2000. Naturalization and invasion of alien plants: concepts and definitions. Diversity and Distributions 6:93–107.

Ridley, H.N. 1930. The Dispersal of Plants throughout the World. L. Reeve and Co., Ltd., Ashford, Kent. 744 p.

Schmutz, E., B. Freeman, and R. Reed. 1968. The Livestock Poisoning Plants of Arizona. University of Arizona Press, Tucson. 176 p.

Squires, V.R. 1969. Ecological factors contributing to the success of *Tribulus terrestris* L. as a weed in a winter rainfall environment in southern Australia. Proceedings of the Ecological Society of Australia 4:55–66.

Squires, V.R. 1979. The biology of Australian weeds. 1. *Tribulus terrestris* L. Journal of the Australian Institute of Agricultural Science 45:75–82.

[USDA] U.S. Department of Agriculture, Natural Resources Conservation Service. 2005. The PLANTS Database, Version 3.5. Available online at: http://plants.usda.gov. Data compiled from various sources by Mark W. Skinner. National Plant Data Center, Baton Rouge, Louisiana.

Warner, P.J., C. Bossard, M.L. Brooks, J.M. DiTomaso, J.A. Hall, A. M. Howald, D.W. Johnson, J.M. Randall, C.L. Roye, M.M. Ryan, and A.E. Staton. 2003. Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands. Available online at: www.caleppc.org and www.swvma.org. California Exotic Pest Plant Council and Southwest Vegetation Management Association. 24 p.

[WSNWCB] Washington State Noxious Weed Control Board. 2001. Puncture vine (*Tribulus terrestris* L.). Available online at: http://www.wa.gov/weed_info/punctureVine.html; accessed June 2003.

Whitson, T.D. (ed.). 1992. Weeds of the West. The Western Society of Weed Science in cooperation with the Western United States Land Grant Universities Cooperative Extension Services and the University of Wyoming. 630 p.